HAMMERSTEIN AND WIENER MODEL IDENTIFICATION USING RATIONAL ORTHONORMAL BASES

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***Abstract*— In this paper, non iterative algorithms for the identification of (multivariable) Hammerstein and Wiener systems are presented. The proposed algorithms are numerically robust, since they are based only on least squares estimation and singular value decomposition. For the Hammerstein model, the algorithm provides consistent estimates even in the presence of coloured output noise, under weak assumptions on the persistency of excitation of the inputs. For the Wiener model, consistency of the estimates can only be guaranteed in the noise free case. Key in the derivation of the results is the use of rational orthonormal bases for the representation of the linear part of the systems.**

***Keywords*— Hammerstein and Wiener models, Nonlinear Identification, Singular Value Decomposition.**

I. INTRODUCTION

In the last decades, a considerable amount of research has been carried out on modelling, identification, and control of nonlinear systems. Most dynamical systems can be better represented by nonlinear models, which are able to describe the global behaviour of the system over the whole operating range, rather than by linear ones that are only able to approximate the system around a given operating point. One of the most frequently studied classes of nonlinear models are the so called *block-oriented nonlinear models* (Pearson and Pottmann, 2000), which consist of the interconnection of Linear Time Invariant (LTI) systems and static (memoryless) nonlinearities. Within this class, two of the more common model structures are:

- the **Hammerstein** model, which consists of the cascade connection of a static (memoryless) nonlinearity followed by a LTI system (see for instance (Eskinat *et al.*, 1991) for a review on identification of Hammerstein models), and
- the **Wiener** model, in which the order of the linear and the nonlinear blocks in the cascade connection is reversed (see for instance (Greblicki, 1994), (Wigren, 1993), (Wigren, 1994) for different methods for the identification of Wiener models).

These model structures have been successfully used to represent nonlinear systems in a number of practical applications in the areas of chemical processes (Eskinat *et al.*, 1991), (Pearson and Pottmann, 2000), (Kalafatis *et al.*, 1995), (Chou *et al., 2000*), biological processes (Korenberg, 1978), signal processing, communications, and control (Fruzzetti *et al.*, 1997).

Several techniques have been proposed in the literature for the identification of Hammerstein and Wiener models. The reader is referred to (Narendra and Gallman, 1966), (Billings, 1980), (Billings and Fakhouri, 1982), (Eskinat *et al.*, 1991), (Greblicki and Pawlak, 1989), and the references therein, for identification of Hammerstein models; and to (Billings, 1980), (Wigren, 1993), (Wigren, 1994), (Greblicki, 1994), (Hagenblad and Ljung, 2000), and the references therein, for identification of Wiener models. For the purpose of putting into context the present work, three main approaches for the identification of Hammerstein and Wiener models will be distinguished. The first one is the traditional iterative algorithm proposed by Narendra and Gallman in (Narendra and Gallman, 1966). In this algorithm, an appropriate parameterization of the system allows the prediction error to be separately linear in each set of parameters characterizing the linear and the nonlinear parts. The estimation is then carried out by minimizing alternatively with respect to each set of parameters, a quadratic criterion on the prediction errors. A second approach, based on correlation techniques, is introduced in (Billings, 1980). This method relies on a separation principle, but with the rather restrictive requirement on the input to be white noise. A more recent approach for the identification of single-input/single-output (SISO) Hammerstein-Wiener systems has been introduced by